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Semi-Annual Report 1

RESEARCH-ENGINEERING AND SUPPORT FOR TROPICAL COMMUNICATIONS

By: *W. R. Vincent*

Prepared for:

U.S. ARMY ELECTRONICS RESEARCH AND DEVELOPMENT LABORATORY
FORT MONMOUTH, NEW JERSEY

PR&C NO. 63-ELN/R-6109
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STANFORD RESEARCH INSTITUTE

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Order-371

By: (10) W. R. Vincent.

(16) SRI-4240

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(332 500) Amk

ABSTRACT

→ The purpose of the project is to support the Combat and Development Test Center, a joint Thailand-United States agency, in the areas of tactical and tropical communications. The United States Army Electronics Research and Development Laboratory and ~~Stanford Research Institute~~ ^{Amphur} have created in Bangkok a Communications Research Laboratory, to be staffed by both Thai and United States personnel. This laboratory is presently housed in a van complex. A C-2 vertical sounder, supplied by the United States Army Radio Propagation Agency, is being used for the study of the equatorial atmosphere. A remote area has ~~been~~ ^{was} established for testing man-pack radio sets in a tropical environment. Word lists in the Thai language are being prepared, with cooperation from the United States Army Language School at Monterey, for use in this testing. ↗

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I INTRODUCTION

A. HISTORICAL BACKGROUND

During World War II, United States military forces operated extensively in tropical areas, thus gaining considerable practical experience in communication problems in tropical forest and jungle areas. The pressure of military objectives limited scientific explorations into many of the specific problems that arose, resulting in sizeable gaps in our knowledge of communication in equatorial regions.

The friendly and cooperative working arrangement existing between Thailand and the United States has resulted in the joint study of tropical communication problems by staff members of the Thailand Ministry of Defense and agencies of the United States. The Combat and Development Test Center (CDTC) has been organized as a joint Thailand-United States agency to conduct operational tests of military hardware and to foster research on many subjects in a tropical environment. Communications research is a major subject of interest in the CDTC.

The United States Army Electronics Research and Development Laboratory and Stanford Research Institute have undertaken the task of establishing a Communication Research Laboratory in Thailand, to facilitate a first-hand study of tropical communication problems. Staffing of the laboratory is planned as a joint United States-Thailand venture, with United States participation largely from members of the staff of Stanford Research Institute.

Over-all direction of the United States portion of the CDTC has been assigned to the Advanced Research Projects Agency (ARPA) of the Department of Defense. ARPA actively monitors and directs the work of the United States Army Electronics Research and Development Laboratory and its contractor, Stanford Research Institute.

B. OBJECTIVES

The purpose of the project under Contract DA-36-039-AMC-00040(E) is to support the CDTC-T in the areas of tactical and tropical communication. The specific objectives of this effort are:

- (1) To survey, analyze, and evaluate the capacity, reliability, and physical and tactical limitations of existing communication equipments and techniques.
- (2) To generate from the above survey, analysis, and evaluation a set of requirements for field communications based upon tactical considerations and specific equipment characteristics that will satisfy these requirements.
- (3) To test off-the-shelf equipments that come as close as possible to satisfying each set of the above requirements, these tests to be first technical and then tactical for items that show promise.
- (4) To analyze and evaluate the tests and recommend areas for future emphasis.
- (5) To state equipment requirements to accomplish the task of jungle field communication, based upon existing and anticipated tactical requirements.
- (6) To train the Thai personnel assigned to the Communication Laboratory so that they are able to utilize the facility, accomplishing this training as a natural course of operating the laboratory.
- (7) To aid electronic projects in Thailand as practical, encouraging projects that appear especially useful to the basic objectives of CDTC-T.
- (8) To field test selected items of communication equipment in Thailand in accordance with the requirements of the President's Counter Insurgents Committee.

II MAJOR ACCOMPLISHMENTS TO DATE

A. SITE SURVEY

In December 1962, a field site survey was conducted for the purpose of locating a suitable site near Bangkok for the Communication Laboratory and associated field experiments. Mr. W. R. Vincent of Stanford Research Institute and Mr. Howard Kitts of the United States Army Electronics Research and Development Laboratory participated in the site survey. Major John Kranz, the on-site representative of the USAERDL, assisted in liaison with Thailand Ministry of Defense personnel and the CDTC, and in many other useful ways.

The site survey resulted in the selection of a suitable site location near the northern edge of Bangkok (see Fig. 1) where a three-story Chinese-style store building existed (adaptable for headquarters), and adequate rice-paddy land was available. Tentative lease arrangements were completed with the building and land owners. The building is shown in Fig. 2.

The Jansky and Bailey Corporation had, fortunately, just completed a survey of Thailand for remote propagation test sites in tropical rain-forest areas. Their survey was completed under a companion program also under the direction of ANPA and the USAERDL. Sharing of remote sites was planned, and considerable use was made of material gathered for their survey.¹

B. ESTABLISHMENT OF LABORATORY FACILITIES

Information obtained from the field site survey indicated that a suitable field site and laboratory building complex did not exist in or near Bangkok. Both construction time and costs for a laboratory building appeared excessive. Since the Thailand Government had tentative plans to establish a research facility in two or three years, it was decided to create the laboratory portion of the facility in a complex of vans. Consequently, a complex of three interconnecting vans was designed (see

¹ Jansky and Bailey Site Survey Report.

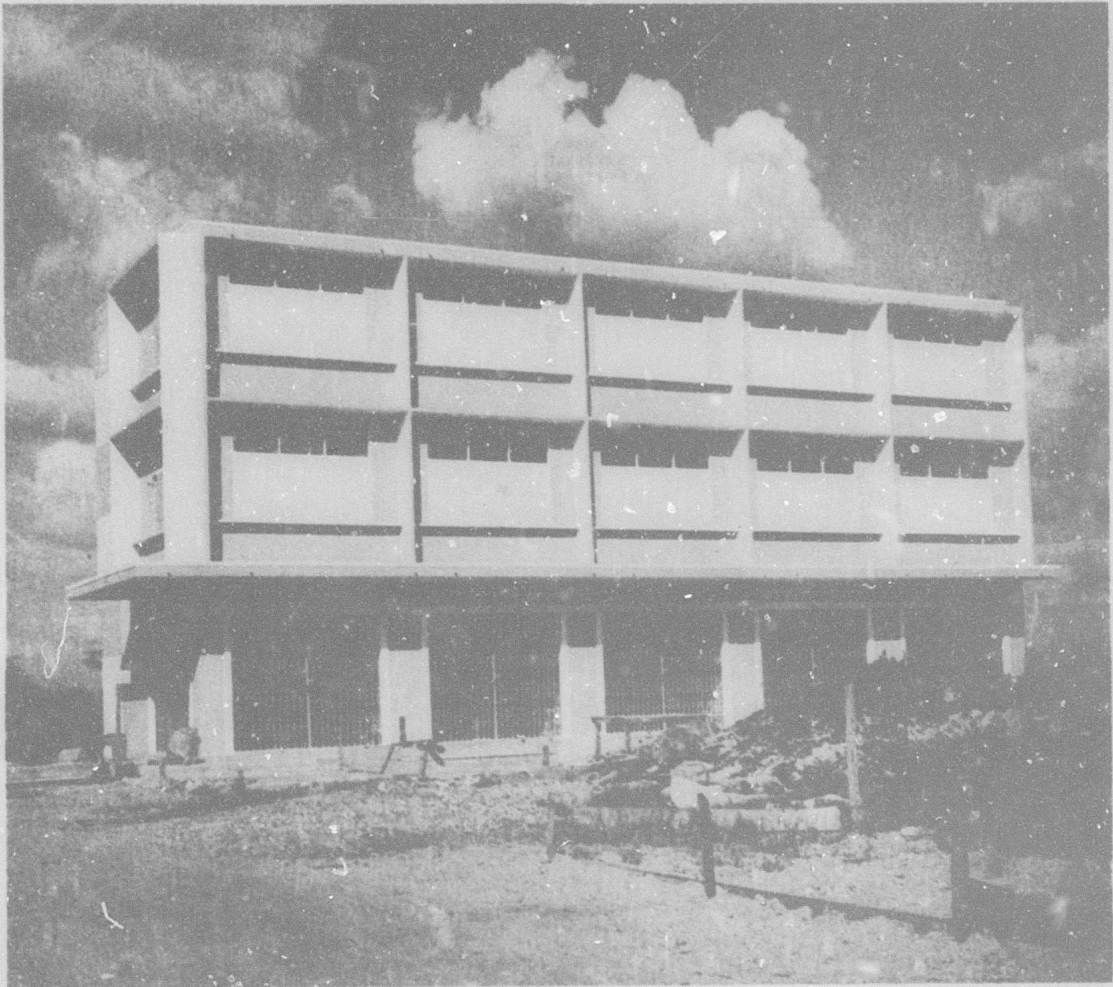


FIG. 2 PHOTOGRAPH OF HEADQUARTERS BUILDING

Fig. 3). Lists were prepared of scientific equipment, electronic parts, auxiliary equipment, and supplies required for one year's operation. Due to the extensive construction required to make the van complex available in a short time, the USAERDL enlisted the aid of the Electronics Defense Laboratory (EDL) of the Sylvania Corporation for these tasks. Due to the close proximity of EDL and SRI, an excellent working arrangement was established whereby laboratory characteristics and requirements were fed to EDL in an informal manner, resulting in the rapid creation of an excellent laboratory facility equipped with adequate electronic instruments and supplies. A photograph of the laboratory complex is shown in Fig. 4.

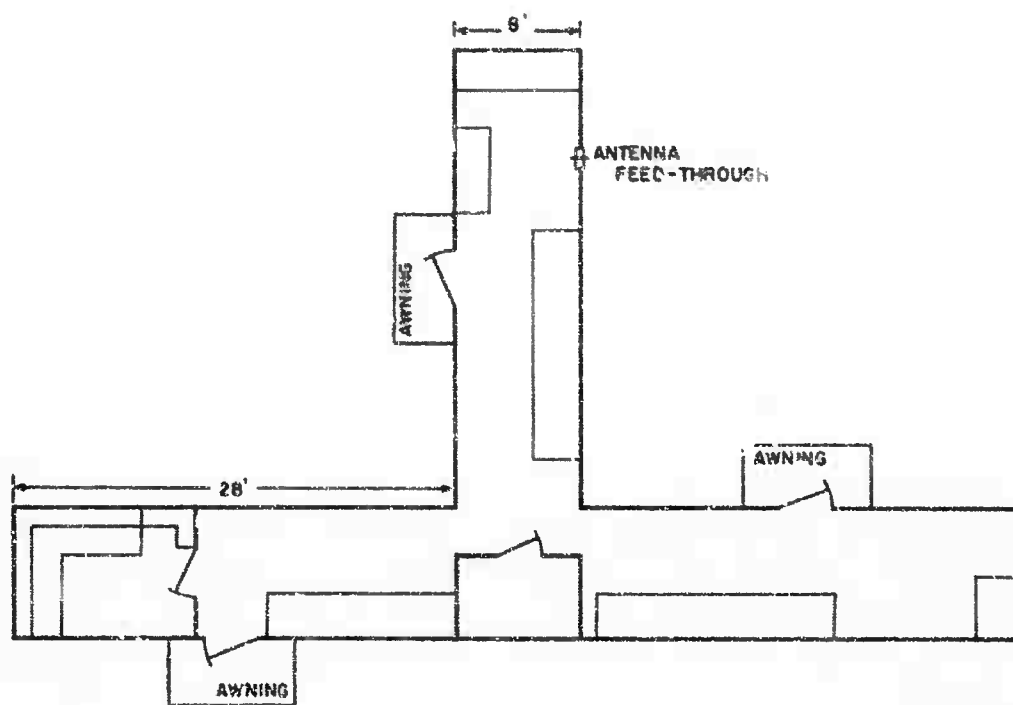
Four small portable laboratory vans were also constructed by Sylvania to provide adequate working arrangements in remote areas. The portable vans were patterned after military S-141/G type vans which are transportable by 2½-ton 6 × 6 trucks or their equivalent. The interiors contain work benches, relay racks, and storage cabinets found necessary for field operation.

In addition to the laboratory vans, a C-2 vertical sounder was supplied by the United States Army Radio Propagation Agency of Fort Monmouth, New Jersey, for the study of the equatorial ionosphere. Arrangements were made to locate the C-2 sounder near the van complex so that logistics problems could be minimized and scientific devices could be concentrated in one area. The vertical sounder was supplied, installed in a standard semitrailer van.

C. SITE PREPARATION

An advance party of SRI personnel arrived in Thailand in February 1963 to complete lease arrangements and to start preparation of the site to receive the laboratory van complex. Additional permanent staff will arrive in Thailand during March and April, to supervise site work and handle all details related to the establishment of a communication research laboratory.

A contract was established with the Office in Charge of Construction, South East Asia Area, to fill an area of rice paddy land and pour concrete pads for the vans. A separate fill area and concrete pad was made for the C-2 sounder supplied by the USARPA.



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FIG. 3 GENERAL LAYOUT CDTC-T LABORATORY T-COMPLEX

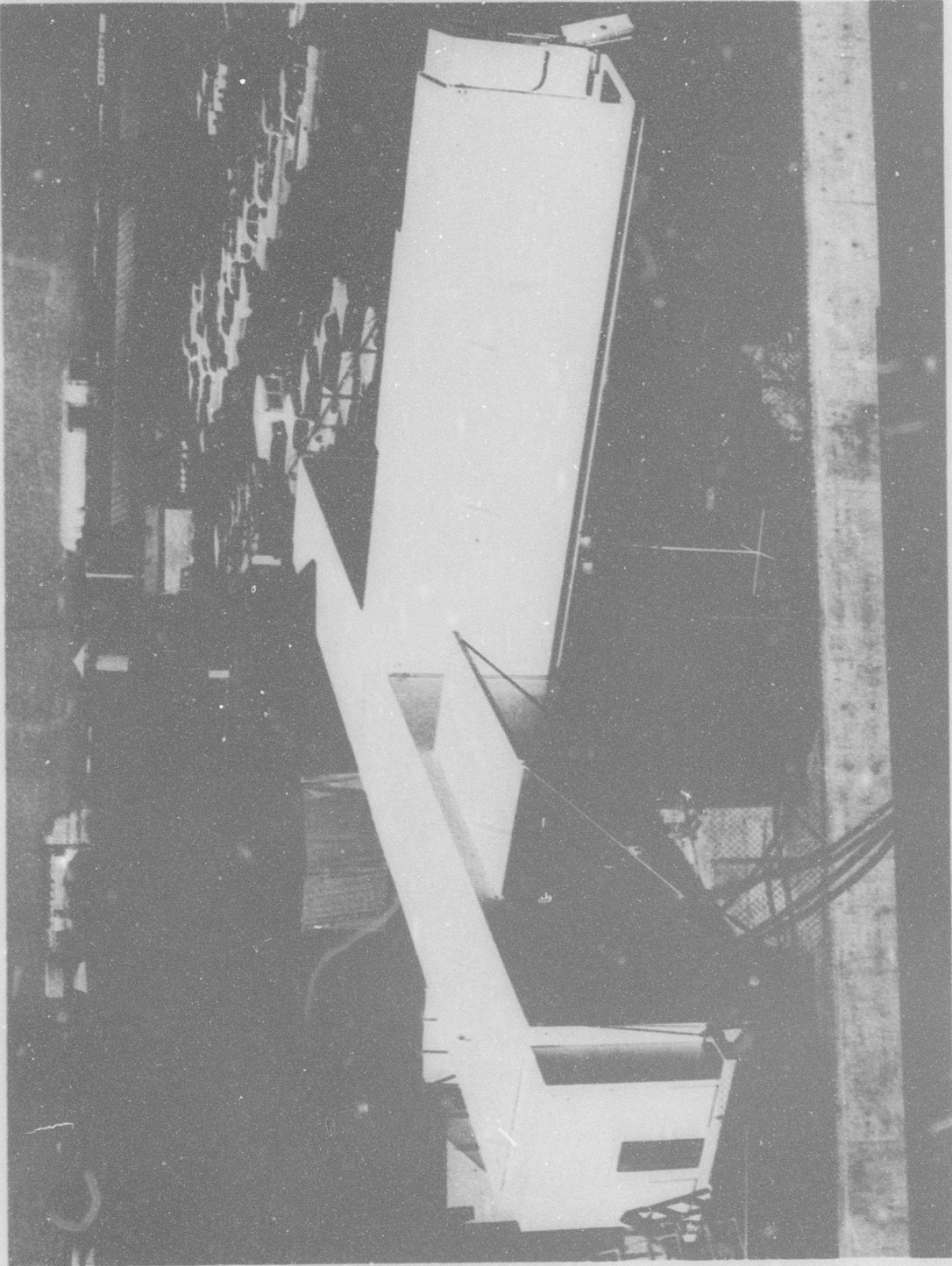


FIG. 4 PHOTOGRAPH OF LABORATORY COMPLEX

The Chinese style building shown in Fig. 2 was leased as a headquarters and auxiliary laboratory building. Although the building was new, it was constructed to Thailand standards, and required considerable modification prior to occupancy. The building consisted of five separate bays with a solid wall separating each bay. It was necessary to establish access between bays on each floor by making doors in the brick dividing walls. Air conditioning, electric wiring, floor coverings, and American style toilets have been installed and other modifications made, making the building an adequate headquarters.

D. REMOTE-SITE PREPARATION

Arrangements were made to establish a remote communication testing area 422 km south of Bangkok in the rain-forest area. This site was selected for initial tests since desirable vegetation features exist, some shelter was available (used as a hunting lodge by its owner, a Bangkok businessman), and it is accessible by road and railroad. A headquarters and living area were made by improving the existing hunting lodge. In addition, test huts were constructed of local materials at ranges of 0, 5, 10, and 23 miles. All test huts were constructed in heavily forested areas. A typical hut is shown in Fig. 5. A map showing the location of the test area is shown in Fig. 6.

E. EQUIPMENT SHIPMENT SCHEDULE

Considerable equipment was shipped to Thailand during the first six months. Major shipments originated from EDL, the USARPA, and SRI. Following is a summary of accomplished and proposed shipments to Thailand.

SHIPPING AGENCY	SHIPMENT DATE	SHIPMENT METHOD	ARRIVAL DATE	COMMENTS
EDL and SRI	14 Feb.	Two C124 aircraft	18 Feb.	Generators, laboratory support equipment and supplies
PPA	Approximately 20 March	Ship, "President Grant"		C-2 sounder
EDL	30 April	Ship, "USS Steel Architect"		Vans and related material
EDL	May	Ship		Scientific equipment

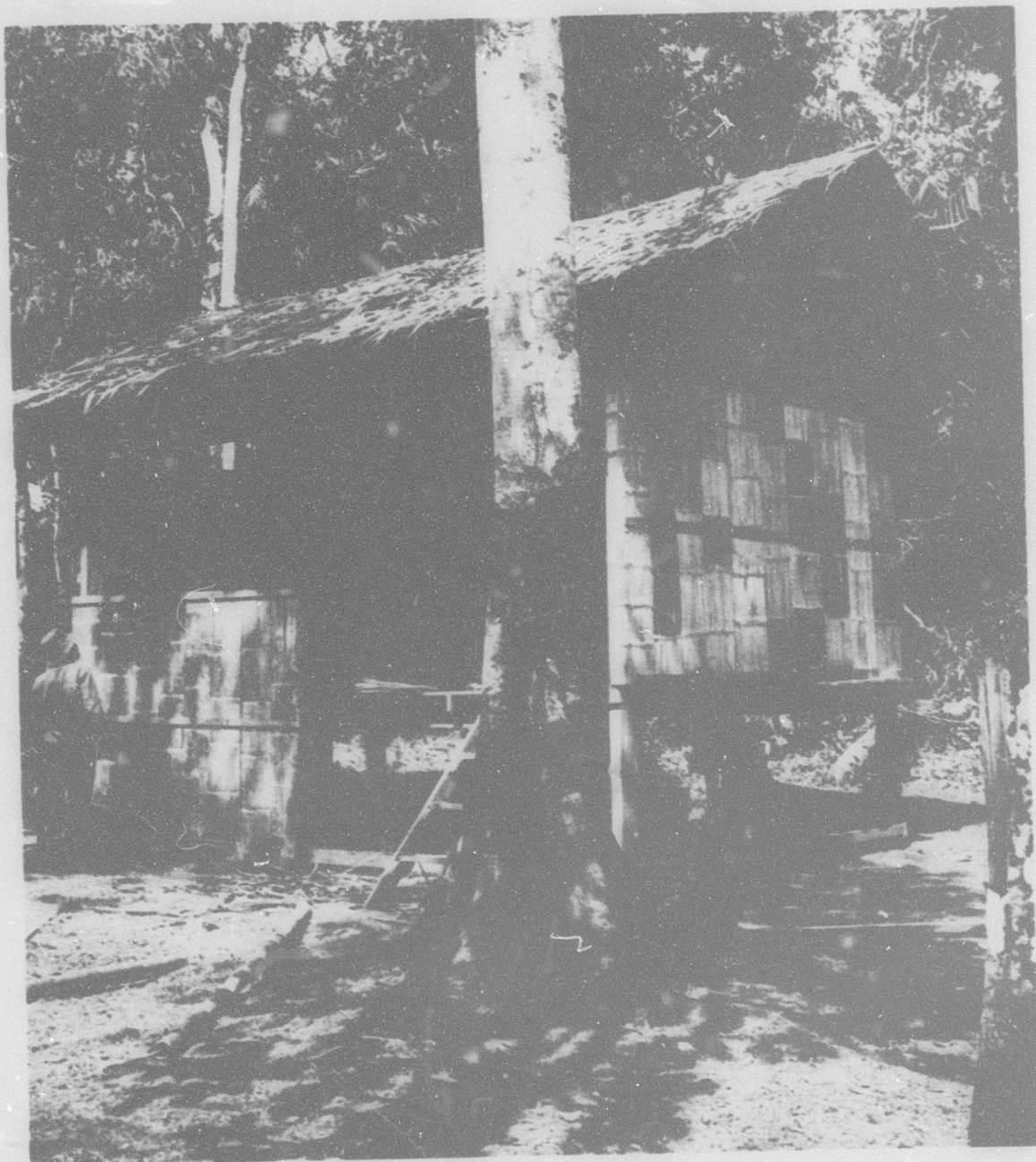


FIG. 5 PHOTOGRAPH OF A TEST HUT

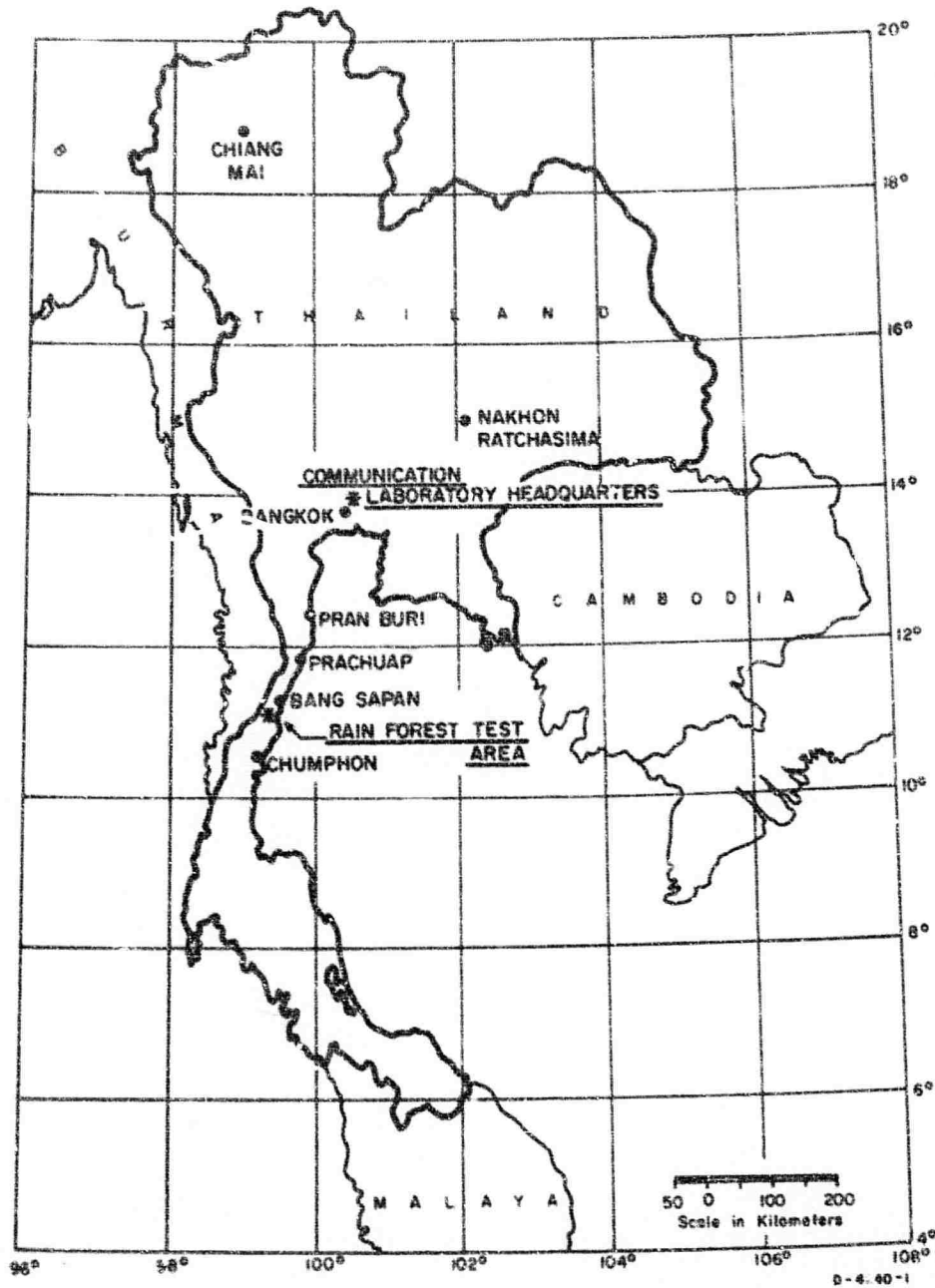


FIG. 6 MAP OF THAILAND

F. COMMUNICATION TEST PROGRAM

The President's Counter Insurgency Committee requested that the Department of Defense conduct field tests in a tropical environment on existing man-pack radio sets. The Communication Laboratory of the CDTC provided a convenient organization with field facilities to conduct such tests. Consequently, SNI was requested to conduct the tests as a part of its field program in Thailand.

A number of man-pack radio sets with the general characteristics shown in Table I were made available for field testing. The Bang Sapan test area was used to conduct the tests. Some general observations are given below.

- (1) Severe absorption of the ground wave was noted in moderately dense rain forest under dry season conditions. At 5 miles range, communication with HF man-pack radio sets was via the ionosphere.
- (2) In view of the dependence on ionospheric propagation at ground-separation distances as short as 5 miles, it has been recommended that oblique ionospheric sounders be employed to graphically display propagation conditions.
- (3) Interference from other HF stations was severe. If a channel was free for a few hours, this was no indication of future interference-free operation. Interference came entirely from distant stations. There is no known technique for selecting channels to avoid interference under conditions found in South East Asia (SEA). Successful communication frequently resulted from channel changing. Sets with a large number of channels clearly had an advantage over those with restricted numbers of channels.

Details on the comparative tests between various sets are complicated and should be presented in a manner that clearly illustrates the problems and test conditions. Consequently, test results are being published in a separate report.

To illustrate how oblique sounders can be used to explore the useful propagation spectrum for short-distance field communication, tests have been conducted on sounders located at Hawaii and Washington naval communication sites. Transmitter-to-receiver spacings of 12 and 25 miles appeared convenient for initial tests. Of course, the antennas were not surrounded by tropical vegetation, and the terrain between the sites could not be classed as a tropical forest area. The conditions existing

Table I

GENERAL CHARACTERISTICS OF MA

RADIO SET	MANUFACTURER	WEIGHT (lb)	POWER OUTPUT	MODULATION	FREQUENCY RANGE (Mc)	NUMBER OF CHANNELS	BAND PASS (kc)	IF FREQUENCY
77-AM	Sylvania	28	6-7 w	CW AM	3-8 Separate plug-in crystals for transmitting and receiving	6 Can be changed with plug-in crystals	5-6	455 kc
TRC-88	Sylvania	27	10-14 w on CW 10 w on SSB	CW SSB FSK	3-8 Separate plug-in crystals for transmitting and receiving	6 Can be changed with plug-in crystals	5-6	455 kc
TRP-4	Oki Radio	30	2 w	SSB	2.5-7.5	6 Can be changed with plug-in crystals	3	455 kc
HC-162	Hughes	20 or 25	15 w	CW SSB	2-11.99	Tunes to 1-kc increments from 2 to 12 Mc	2.7 at 3 db 3 at 6 db	1750 kc 3250 kc (upper or lower frequency)
PRC-25	RCA	17	1.5 w	FM	30-75.95 13 crystals	Continuous 50-kc increments	35	11.5 Mc
PRC-35	RCA (Experimental model)	10	30 mw	FM	30-69.9 19 crystals	4 800 possible in 50-kc increments with crystals	40	10 Mc
PRC-10	Admiral	--	1 w	FM	38-55	Continuous tuning	--	--

Table I

CHARACTERISTICS OF MAN-PACK RADIO SETS

BAND PASS (kc)	IF FREQUENCY	UNITS ON HAND	UNITS CAN BE RUN FROM VEHICLE	BATTERY INFORMATION	ANTENNA INFORMATION
5-6	455 kc	10	Yes on 12 v system	Rechargeable Voltage: 12 v Capacity: 4 ah Receiving current: 16 ma Transmitting current: 3.5-4 a Charge time: 4 hr using AC charger; 2 hr using DC charger (24 v) Weight: 16 lb Has 12 v external terminals for auxiliary equipment Interchangeable with TRC-88	3 slant wire antennas: 28, 40, and 57 ft 2-wire counterpoise 50 ft long Interchangeable with TRC-88
5-6	455 kc	4	Yes on 12 v system	Rechargeable Voltage: 12 v Capacity: 14 ah Receiving current: 16 ma Transmitting current: 2-3.7 a Charge time: 4 hr using AC charger; 2 hr using DC charger (24 v) Weight: 10 lb Has 12 v external terminals for auxiliary equipment Interchangeable with 77-AM	3 slant-wire antennas: 25, 40, and 57 ft 2-wire counterpoise 50 ft long Interchangeable with 77-AM
3	455 kc	4	No	Rechargeable Voltage: 6 v Capacity: 10 ah Receiving current: 4 ma Transmitting current: 1 a Charge time: 10 hr (has charge meter on front panel) Weight: 17.6 lb Duty cycle: 5-1	3 types: (1) Whip (2) $\frac{1}{4}$ -wave wire with counterpoise (3) $\frac{1}{4}$ -wave wire; use on 4 Mc only
2.7 at 3 db 3 at 6 db	1750 kc 3250 kc (upper or lower fre- quency)	3	No	Rechargeable 2 types: (1) Voltage: 12 v Capacity: 4 ah Charge time: 24 hr at $\frac{1}{4}$ ah Weight: 7 lb (2) Voltage: 12 v Capacity: 14 ah Charge time: 4 hr at 5 ah Weight: 12 lb	4 slant-wire antennas: 19, 31, 43, and 63 ft 20-ft counterpoise wire Dipole output at 72 ohms provided
35	11.5 Mc	2	Yes on 24 v system	Dry, disposable Voltage: 2 types (1) 0 + 3 + 15 v with DC-to- DC converter (2) +3 + 15 + 150 v Capacity: 20 ah Weight: 3 lb 12 oz (HV type) Duty cycle: 9-1	Whips, 3 and 10 ft 3-ft whip interchangeable with PRC-35 antenna whips
40	10 Mc	3	No	Dry, disposable Voltage: 26 v Capacity: 10 ah Weight: 1.25 lb Duty cycle: 9-1	Steel-tape whip, 3 ft 2 types: (1) One has flexible base (2) Other does not Both interchangeable with 3-ft whip on PRC-25
--	--	8	No	Dry, disposable Voltage: -6 + 1.5 + 67.5 + 135 v	2 types: (1) Steel-tape short whip (2) Long whip

should result in a stronger ground wave than in a tropical forest area; indeed such a ground wave can be observed in the results shown in Figs. 7 and 8. If the ground wave did not exist (as noted in Thailand), then propagation would be via the ionospheric modes clearly shown in the examples. Thus an oblique sounder can:

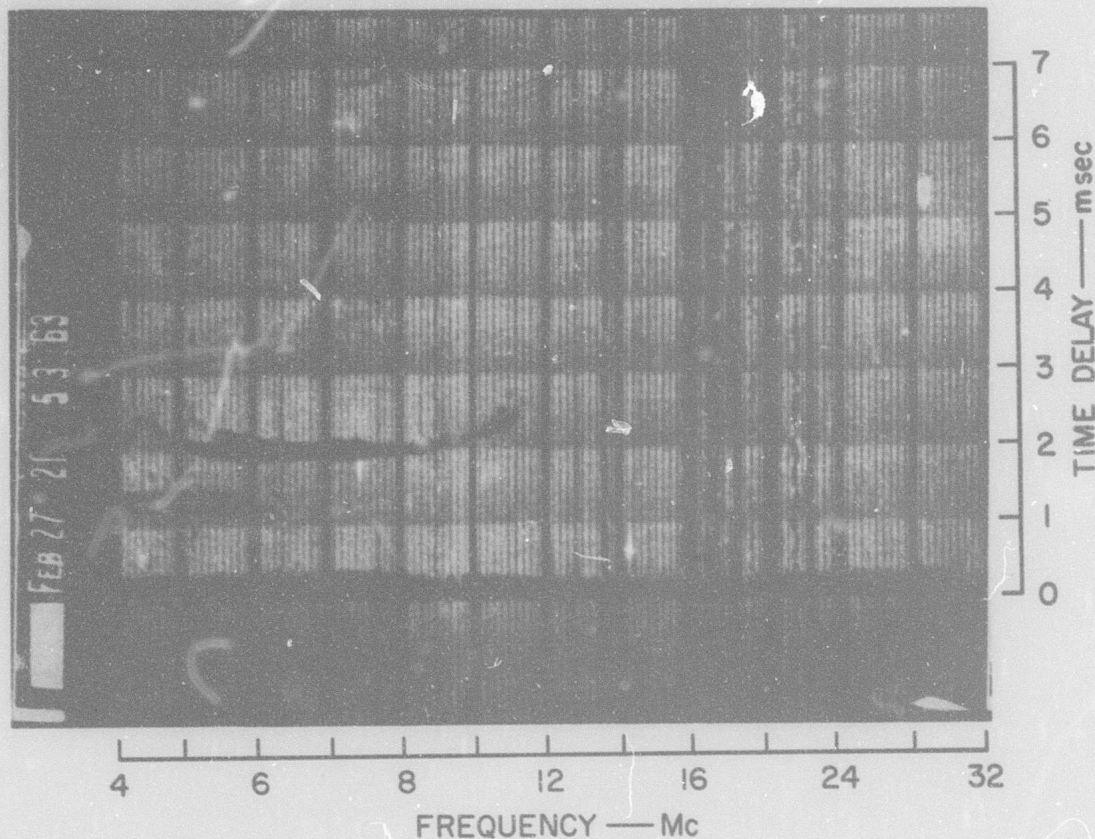
- (1) Determine the region of the HF spectrum that will support low-power field communications.
- (2) Illustrate how the useful spectrum changes between day and night.
- (3) Present multipath conditions so that errors in transmission caused by severe multipath can be properly explained.
- (4) Show the relative contribution of ground-wave and ionospheric propagation; also show the effects of enhancement due to anomalous ionospheric layers such as sporadic E, which is prevalent in equatorial regions.
- (5) Become an excellent educational tool, teaching operators the true nature of the propagation path between two field stations.
- (6) Provide data leading to the determination of accurate reliability figures for field communication.
- (7) Compare the relative performance of various antennas used for man-pack radio set operation.

G. VOICE COMMUNICATION TESTING AND EVALUATION

The testing of man-pack radio sets in Thailand is currently being accomplished by human operators. The test results, therefore, must be treated with some caution, due to the large variability from operator to operator and to operator variations due to fatigue, interest, and environmental changes. While the current test results can uncover major differences between radio sets, such tests are not sufficiently precise to uncover subtle differences which may be important.

Equipment has been ordered to permit the use of a tape recorder to modulate the radio sets. Standard tape word lists are used to avoid language problems. Another tape recorder is used to record the receiver signals, and a selected audience is then used to evaluate over-all performance. The audience, of course, is not aware of the particular radio set under test.

Word lists in the Thai language are also being prepared with the much appreciated assistance of the United States Army Language School at Monterey, California, and several Thai graduate students at Stanford University.

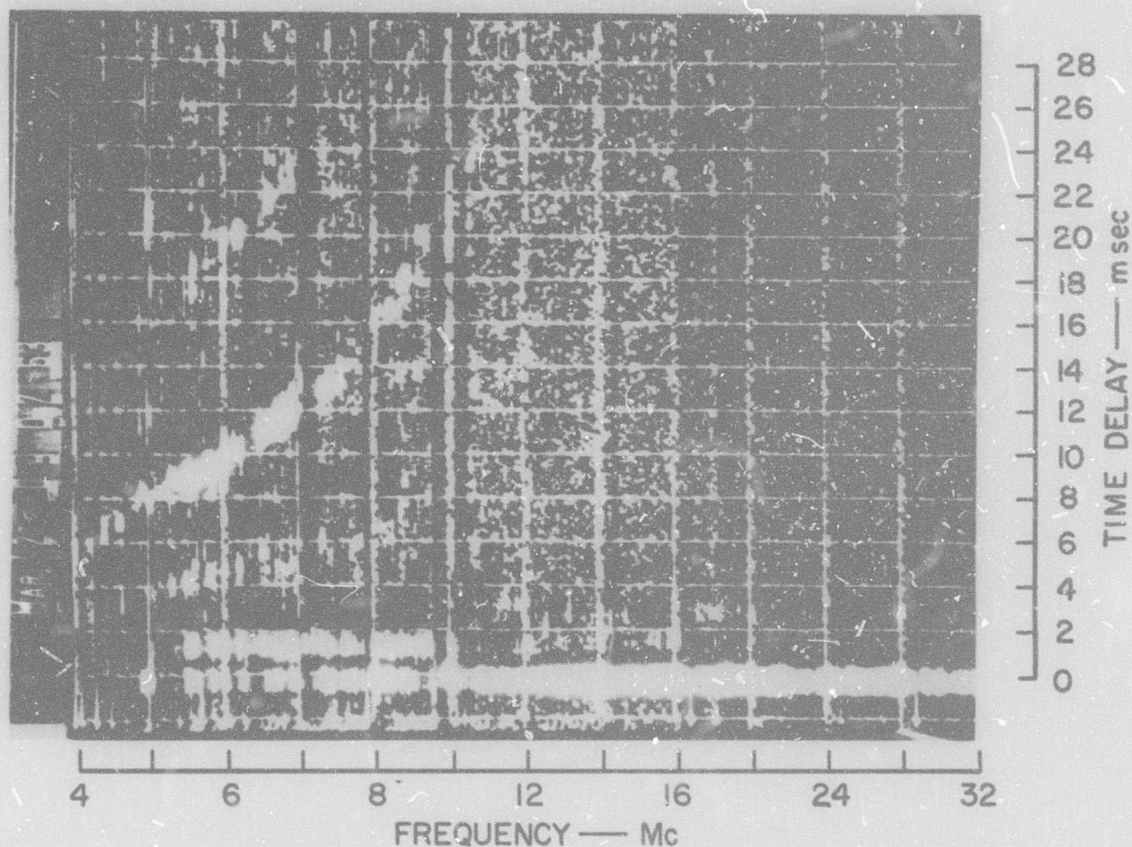


This ionogram was taken by a Model 903a Pathfinder sounder receiver operated by Stanford Research Institute at Wahiawa, Hawaii. The sounder transmitter is located at Lualualei, 12 air miles distant. The rhombic antennas, at both sites, are on a bearing of 054° true.

Near-vertical-incidence signals appear just above the 2-msec range mark at frequencies between 4.4 and 11.4 Mc. The 100- μ sec pulses permit separation of the ordinary and extraordinary rays. Direct path signal exists from 4 to 32 Mc at 0-msec range.

The horizontal signals between 4 and 6 Mc at a delay of approximately 1.4 msec are believed to be off-path radar type echoes from sporadic-E patches.

FIG. 7 IONOGRAM — WAHIAWA, NEAR-VERTICAL-INCIDENCE SIGNALS WITH 100- μ sec PULSES



This ionogram was taken by a Model 903a Pathfinder sounder receiver operated by Stanford Research Institute at Cheltenham, Maryland. The sounder transmitter is located at Annapolis, 27 air miles distant. The rhombic antennas, at both sites, are on a bearing of 283° true.

Near-vertical signals appear just above the base line extending from 5.5 to 9 Mc. The time delay is constant at about 1.8 msec.

One-hop backscatter extends from 4 to 10 Mc with time delays ranging from 6 to 20 msec. A trace of two-hop backscatter can be seen between 5.5 and 7 Mc, time delays from 17 to 24 msec. Direct path signal is shown at 0-msec delay.

FIG. 8 IONOGRAM - CHELTENHAM, BISTATIC BACKSCATTER AND NEAR-VERTICAL SIGNALS

III PROGRAM FOR THE NEXT REPORTING PERIOD (1 March to 31 August 1963)

- (1) Complete present field tests on man-pack radios and publish test results.
- (2) Install the laboratory facility in Bangkok and begin actual operation.
- (3) Continue the long-term program planning and initiate selected technical investigations.
- (4) Transfer Professor Robert Leo, on leave from Montana State College, to Bangkok as Head of Technical Programs. Improve the general technical level of personnel and programs in Thailand.
- (5) Complete the equipment and procedures for the precise testing of field radio sets. Review the Thai word lists with personnel in the Thailand Ministry of Defense.
- (6) Further examine the application of oblique sounders to field communication problems.
- (7) Initiate an antenna study program leading to new concepts for antennas designed to maximize communication between field army radio sets.

IV PUBLICATIONS AND CONFERENCES

No publications were issued during the first reporting period of the contract. Several publications are in rough draft form and will be issued during the next reporting period. They are on the following topics:

- (1) Field Testing of Man-Pack Radios
- (2) Voice Communication Testing and Evaluation
- (3) Field Test Program Objectives.

Several conferences have been held between project personnel and other parties. A summary of these conferences follows.

- (1) On 18 October 1962, Mr. George Hagn met with representatives of Jansky and Bailey in Alexandria, Virginia, and on the following day with Mr. Kitts and Mr. Watts at Fort Monmouth, New Jersey. The purpose of the visit was to coordinate project activities with the sponsoring agency and with other related activities planned in Thailand by Jansky and Bailey.
- (2) On 29 November 1962, Mr. A. J. Mandelbaum and Mr. R. E. Morse visited Hq. Sixth Army, Presidio of San Francisco, to acquire details of United States programs and interests in Thailand.
- (3) On 10 December 1962, Mr. W. R. Vincent visited Thailand to participate in initial site surveys.
- (4) In January 1963, Mr. Vincent made a trip to Washington, D.C. to coordinate project activities with ARPA and Signal Corps personnel and to make plans for summarizing findings from the December trip to Thailand.
- (5) During February, Mr. Vincent, Mr. J. Ratliff, and Mr. C. F. Hilly visited Thailand to complete land and building lease negotiations and accomplish tasks required to organize a laboratory complex in Thailand. Also, arrangements were made to receive technical personnel in Thailand and to start the field testing of man-pack radio sets.
- (6) From 13 to 16 February 1963, Mr. Mandelbaum and Mr. W. R. Roberts visited the USAEPG, Fort Huachuca, Arizona, to obtain information on techniques used for the field testing of communication systems and equipments.

- (7) On 25 February 1963, Mr. Mandelbaum and Mr. Roberts visited the U.S. Army Language School, Presidio of Monterey, California, to obtain information on the technical details of the Thai language and to determine testing procedures that can be used to evaluate radio sets used by Thai nationals.

V IDENTIFICATION OF KEY TECHNICAL PERSONNEL

For the period 12 September 1962 through 28 February 1963

	HOURS CHARGED TO THE PROJECT
A. S. DENNIS Physicist, Aerophysics Laboratory	5
A. W. FULLER Development Engineer, Support Services Group	800
P. H. GAVER Program Manager, Operations Analyst Department	10
G. H. HAGN Research Engineer (Project Leader), Communication Laboratory	468
G. D. KOEHRSON Project Administrative Aide, Communication Laboratory	314
A. J. MANDELBAUM Operations Analyst, Operations Analyst Department	200
R. E. MORSE Operations Analyst, Operations Analyst Department	164
A. M. PETERSON Assistant Director, Electronic and Radio Sciences Division	4
R. A. RACH Assistant Laboratory Manager, Communication Laboratory	108
W. R. ROBERTS Operations Analyst, Operations Analyst Department	96
W. R. VINCENT Laboratory Manager, Communication Laboratory	336
W. N. WARD Field Engineering Representative, Communication Laboratory	248
G. S. WILEY Department Manager, Operations Analysis Department	12

Dennis, Arnett S. - *Physicist, Radar Aerophysics Group,
Aerophysics Laboratory*

Dr. Dennis joined the staff of Stanford Research Institute in September 1960 on a part-time basis and became a full-time employee in April 1961. He is primarily concerned with the effects of weather conditions on the performance of radar sets and radio communications systems.

In 1955 Dr. Dennis joined the staff of the Weather Modification Company of San Jose, California. He has been a Director of the company since 1956 and was Vice-President from 1956 to April 1961. During this period he was responsible for the conduct and evaluation of the company's rainfall-increasing and hail-suppression experiments, which were scattered over nine states, including California.

Dr. Dennis was graduated from Acadia University at Wolfville, Nova Scotia, Canada, with honors in Physics, in 1949. From 1949 to 1951 he was employed by the Meteorological Service of Canada as an aviation meteorologist at various Royal Canadian Air Force stations. He did post-graduate work in Physics at McGill University in Montreal and received an M.Sc. degree in Physics in 1953 and a Ph.D. degree in 1955. During the summers he did research work for the University in radar meteorology and for Bell Telephone Laboratories at Murray Hill, New Jersey, in transistor development.

Dr. Dennis is a Professional Member of the American Meteorological Society. He has had scientific papers published by the American Meteorological Society and by the American Society of Civil Engineers.

Fuller, Alfred W. - *Development Engineer, Equipment
Engineering Group*

Mr. Fuller's early experience included work as an engineer in a broadcasting station, as a foreman in the Exhaust Department of Heintz and Kauffman Company, and as a final test inspector for airborne radar antennas for Dalmo Victor Company. Following World War II, he engaged in design, construction, and installation of mobile transmitter-receivers for police and fire departments and for private aircraft. Prior to joining the staff of Stanford Research Institute in 1949, he had his own company, installing and maintaining communications equipment.

Mr. Fuller's work at the Institute has been concerned with the design and construction of single-sideband transmitters, computers, electronic surveillance equipment, systems monitoring equipment, and equipment for gathering weather information.

Gaver, Pierce H., Jr. - *Senior Operations Analyst,
Operations Analysis Department*

Mr. Gaver is presently directing a study group involved in research on future communication requirements for the command-control functions of the military services. This work includes communications traffic analysis and operational-communications planning for limited and nuclear war in 1965-1970.

Mr. Gaver has participated on a research team on the future requirements for sea-based deterrence systems of the 1965-1970 era.

As an Operations Analyst for the Management Sciences Department in the Economics Research Division, Mr. Gaver has directed and conducted studies in the evaluation of weapon and environmental communication systems availability, particularly with respect to leadtimes for development, procurement, and deployment of these systems.

Mr. Gaver attended the University of Maryland and received a B.S. degree in Engineering from the United States Military Academy (1948). Advanced military studies have included Russian language and area studies; the Officers' Guided Missile Specialists' course, Fort Bliss, Texas; the Special Weapons course, Fort Leavenworth, Kansas; and the Officers' Advanced Artillery course. Mr. Gaver has done graduate work toward an M.A. degree in History. He is an honors graduate of the Industrial College of the Armed Forces correspondence course, "Economics of National Security."

Before joining the staff of Stanford Research Institute, Mr. Gaver served in the United States Army from 1948 to 1956. His military service included tours of duty as instructor on the Corporal missile and instructor in surface-to-air missile tactics at the Antiaircraft Artillery and Guided Missile School, Fort Bliss, Texas; administrative officer and instructor at the Chemical-Biological-Radiological School in Germany; instructor at the Mutual Defense Assistance Pact School, Germany; and artillery battery executive and reconnaissance officer.

Hagn, George H. - *Research Engineer, Communication Laboratory*

Mr. Hagn received a B.S. degree in Electrical Engineering from Stanford University in 1959. While a student, he worked for Stanford Research Institute two summers, becoming a member of the staff in September 1959. He earned an M.S. degree in Electrical Engineering from Stanford University in 1961, under their Honors Co-operative Program. While at Stanford he also participated in a student teaching program. Mr. Hagn attended the 1961 Radio Propagation Course of the Graduate School of the National Bureau of Standards, Boulder Laboratories.

At the Institute his work has involved the measurement and analysis of ionospheric phenomena, microwave diffraction, and the scattering of HF radio waves from the earth's surface. He has also conducted airborne antenna pattern measurement programs at HF and microwave frequencies.

Mr. Hagn is a member of the Institute of Radio Engineers and an associate member of the American Geophysical Union.

Koehrsen, Glenn D. - *Administrative Assistant,
Communication Laboratory*

Mr. Koehrsen attended Iowa State University in 1956-1957 and City College of San Francisco in 1957-1958. In January 1963 he received a B.A. degree in Mathematics from San Jose State College, with work in Industrial Administration. In 1953 to 1956 he had served in the U.S. Navy. During that period he attended a six-month Electronics Technicians School, specializing in communications.

In April 1958 Mr. Koehrsen joined the staff of Stanford Research Institute. Among the projects on which he worked as an Electronics Technician and later as a Student Engineer were one concerned with design and construction of VLF satellite receivers; the construction of a specially designed astrometric camera for Lick Observatory, for which he built the control unit; and the establishment of the data reduction facility for the Communication Laboratory. For the latter project he screened and hired personnel, coordinated the procurement of data processing machines, and established work procedures on data handling equipment.

Mandelbaum, Albert J. - *Operations Analyst, Operations
Analysis Department*

Since his association with Stanford Research Institute, Mr. Mandelbaum has been engaged in research and analysis of requirements, current and future, of world-wide strategic military communications systems with particular emphasis on the technical and military factors, as well as on new concepts in the conduct of future war as these affect future communications requirements and improvements.

Mr. Mandelbaum received a B.S. degree from the United States Military Academy, West Point, New York in 1930. Commissioned in the Signal Corps Regular Army, he served as a Unit Signal Officer until 1936, when he attended and graduated from the Advanced Officers' Course, U.S. Army Signal School, Fort Monmouth, New Jersey. Being retained thereafter in the faculty of the Signal School, he specialized in Signal Corps tactics and mobilization planning until 1940. Upon the outbreak of World War II, he became Signal Officer, Sixth Army Air Force, Caribbean Theatre, and planned and directed the installation of a very extensive radio and land-line communications system connecting all U.S. military airfields from Mexico through Latin America to Peru, and along the Antilles to Dutch Guiana. Subsequent to 1943, Mr. (then Colonel) Mandelbaum assumed command of the 4th Army Airways Communication Wing, serving over 135 airfields and other Air Force installations in the China, Burma, and India Theater. Here, he planned and directed the installation and operation of extremely complex radio communication and radio air navigation systems pertaining to Air Traffic Control especially over the densely travelled "Over the Hump" air routes of the Himalayas traversing India, Burma, and China.

In 1946, Colonel Mandelbaum attended the Command and General Staff College, Fort Leavenworth, Kansas. Upon graduation, he commanded the Signal Corps Publications Agency concerned with the preparation of technical texts and manuals for new Signal Corps equipment. In 1948 he became Assistant Commandant of the U.S. Army Signal School. During this period he attended the Advanced Management Program Course at the Harvard Business School. He then served in the Office of the Chief Signal Officer, as Chief of Personnel and Training. With the Korean War he was assigned to the Office of the Assistant Chief of Staff for Logistics in the Procurement Division. In 1953 Colonel Mandelbaum graduated from the

Industrial College of the Armed Forces. Thence he assumed command of the Electronic Warfare Center of the Signal Corps, where he directed research and military exercises in electronic countermeasures. In 1955 he was transferred to Supreme Headquarters Allied Powers Europe, Paris, to become Chief, Telecommunication Branch of the Signal Division. Here he initiated and monitored the implementation of ACE HIGH, the world's largest forward scatter system, for NATO Europe. Here also he planned and implemented the Alert and Atomic Strike Communications System for Allied Command Europe. In 1958 Colonel Mandelbaum returned from foreign service to become Signal Officer, Fifth U.S. Army, Chicago, Illinois, during which period he supervised the construction of the Midwest Relay Center, a modern, complex, fully automatic switching center. In 1960 he retired from the Signal Corps and joined the staff of Stanford Research Institute.

Mr. Mandelbaum is a registered Professional Engineer of the State of Colorado; a Director, San Francisco Chapter, of the Armed Forces Communications and Electronics Association, and a member of the Society of American Military Engineers.

Morse, Robert E. - *Operations Analyst, Operations
Analysis Department*

Mr. Morse joined the staff of Stanford Research Institute in February 1962. He is currently engaged in studies of the Sino-Soviet bloc capabilities as a threat to CONUS, NATO, and Field Army areas.

Mr. Morse has had nearly four years of experience with Sylvania Electric Products, Inc., in the field of electronic systems intelligence analysis. During this period, Mr. Morse became well acquainted with both U.S. and Soviet electronic systems, electronic countermeasures, and electronic counter-countermeasures techniques.

In 1949-1956 Mr. Morse served in the U.S. Army. During this period he attended a number of schools, including: Radar Maintenance, Airborne, Army Language School (Chinese/Mandarin), and the AFPE Intelligence School. His main duties were as an intelligence analyst and as a translator and interpreter.

Mr. Morse graduated from Bradley University in 1958 with a B.A. degree in Political Science and a minor in languages.

Peterson, Allen M. - Assistant Director, Electronics and
Radio Sciences Division

Dr. Peterson attended San Jose State College from 1940 to 1942. He was a member of the Electronics Group of the Sacramento Air Service Command from 1942 to 1944 and from 1944 to 1946 was on active duty with the U.S. Army Air Force.

From the Department of Electrical Engineering at Stanford University he received a B.S. degree in 1948, an M.S. degree in 1949, and a Ph.D. degree in 1952. Since 1947 Dr. Peterson has been a staff member of the Radioscience Laboratory at Stanford. He is currently Professor of Electrical Engineering.

In 1953 Dr. Peterson joined the staff of Stanford Research Institute, where he has been engaged in research on radio propagation, communications, and radio systems design.

Dr. Peterson has been or is currently a member of the following U.S. Government advisory groups:

United States Delegation to the Geneva Conference on Discontinuance of Nuclear Weapons Tests (Technical Advisor, U.S. State Department)

Advisory Group on Detection of Nuclear Explosions, Project VELA (Advanced Research Projects Agency)

Weapons Effects Requirements Board, Panel on Communications and Radar (Defense Atomic Support Agency)

Advisory Group on Electronic Warfare (Office of the Director of Defense Research and Engineering)

U.S. National Committee for the I.G.Y., Technical Panel on Aurora and Airglow (National Academy of Sciences)

Avionics Panel AGARD (Scientific Affiliate, North Atlantic Treaty Organization, NATO).

He is serving as a consultant to:

The President's Science Advisory Committee

Operations Evaluation Group (Office of the Chief of Naval Operations), "Jason Group," Institute for Defense Analysis.

In 1959 Dr. Peterson received the Achievement Recognition Award of the Seventh Region of the Institute of Radio Engineers.

In 1962 he was made a Fellow of the Institute of Electrical and Electronics Engineers.

Dr. Peterson is a member of the IEEE Professional Groups on Antennas and Propagation, on Electronic Computers, and on Information Theory; the Scientific Research Society of America; Sigma Xi; the Society for Industrial and Applied Mathematics; Union Radio Scientifique Internationale; and Commissions III and IV of the United States Committee of URSI. He was a member of a National Science Foundation Panel charged with planning and reviewing auroral and ionospheric research programs conducted during the International Geophysical Year. Dr. Peterson is the author, or co-author of approximately fifty papers in the fields of communications, radio propagation, and upper atmospheric physics.

Rach, Robert A. - *Assistant Manager,*
Communication Laboratory

Mr. Rach received a B.A. degree in Astronomy from the University of California in 1950. He worked at Lick Observatory from 1950 to 1951 as an Observer. From 1951 to 1953 he served with the U.S. Army as a Field Instrumentation Officer and later, in Korea, as Commanding Officer of a Topographic and Meteorological Unit. From 1953 to 1956 he was a graduate student and later Lick Observatory Fellow in Astronomy at the University of California. At Lick Observatory he was concerned with position measurement of stars and spectrographic studies.

In May 1956 Mr. Rach joined the staff of Stanford Research Institute, where he has been engaged in studies of propagation and communication systems and in evaluation of communication networks. Among the projects on which Mr. Rach has acted as leader were projects on telemetry propagation problems connected with missile re-entry, HF propagation prediction by digital computer techniques, digital simulation of the performance of HF communication networks in a normal and jamming environment, and real-time control of world-wide communication networks. Mr. Rach is currently pursuing additional problems in the areas of network vulnerability, planning techniques, network control, HF sounding, backscatter radar, nuclear effects, and satellite communication systems.

Mr. Rach was appointed Assistant Head of the Communication Group in March 1959.

Mr. Rach is a member of the Scientific Research Society of America and Sigma Xi.

Roberts, William R. - *Operations Analyst, Operations
Analysis Department*

Mr. Roberts is presently engaged in engineering research directed toward the evaluation and improvement of speech communication systems, with particular emphasis on those systems that are secure voice systems.

Mr. Roberts received a B.S. degree in Mathematics from Trinity University in 1949, with a minor in Physics. After his discharge from the United States Marine Corps in 1954, Mr. Roberts worked for the City Public Service Board of San Antonio, Texas, where, as a Budget and Statistical Engineer, he prepared statistical analyses of various features of electrical utility service with respect to loads, distribution networks, and construction costs.

In 1956-1957, Mr. Roberts spent a year with the Core Laboratories of Dallas, Texas, as a Junior Engineer. His duties included the extensive analysis of rock samples for porosity, saturations, and permeability. He also prepared estimates of the feasibility of oil production at specified sites.

Mr. Roberts joined Lenkurt Electric Company of San Carlos, California in 1957, as a Design Engineer. In this capacity he was responsible for developing the concept and design of packaging plans for active and passive networks on various communications systems.

During 1959, Mr. Roberts was employed by the Boeing Airplane Company of Seattle, Washington, as a Design Engineer. At Boeing he specialized in manufacturing and packaging techniques for the Minuteman sequence and monitor launch system. He also worked extensively on the console designs for Minuteman.

At the end of 1959, Mr. Roberts joined the ITT Federal Laboratories of Palo Alto, California, as a Senior Member of the Technical Staff. As Project Manager, Mr. Roberts was responsible for several projects involving speech communication systems utilizing bandwidth and amplitude compression devices. He was directly responsible for the development and application of psychophysical techniques used for the evaluation of

speech systems considered for Project 480L AIRCOM, the USAF Global Communication System. This development included an experimental design such that the obtained results could be reproduced with a high degree of statistical validity. He was also responsible for the development of experimental procedures designed to measure the amount of prosodic information imbedded on the phonetic code during speech transduction and transmission, i.e., the amount of information retained by a speech communication system with respect to talker identity, intent of message, emotional status, etc.

He is the author of a paper entitled, "A Judgmental Method for a Voice Communication System Evaluation," published in the 1961 *IRE International Convention Record*.

Vincent, Wilbur R. - *Manager, Communication Laboratory*

Mr. Vincent received a B.S. degree in 1947 and an M.S. degree in 1951, both in Electrical Engineering from Michigan State College. He was a Radio Technician in the U.S. Signal Corps, installing and servicing radio-teletype installations in the Pacific, from 1943 to 1946. In 1948 he joined the Electronics Staff of the Bell Aircraft Corporation as a unit leader in charge of missile communication equipment development.

In October 1955 Mr. Vincent joined the staff of Stanford Research Institute. As a Research Engineer he was engaged in work on meteor-burst communication, auroral-zone communication, and associated communication and propagation studies. He conducted extensive studies and field experiments on the propagation path provided by ionized meteor trails and assisted in the setting up of the Stanford-Montana State College meteor-burst communication system, the first such system to operate in the United States.

Mr. Vincent was appointed Assistant Group Head of the Communications and Propagation Group in 1957, Head of the Communication Group of the Communication and Propagation Laboratory in 1958, and Manager of the Communication Laboratory in 1962. He has conducted studies of communication network analysis, optimum utilization of large imperfect communication networks, the use of electronic computers to solve radio propagation problems and communication network problems, satellite communication, improvements in high-frequency radio, and other related problems.

Mr. Vincent is the author of several papers in the field of communication and radio propagation.

Mr. Vincent is a member of the Institute of Radio Engineers and a member of the IRE Professional Groups on Circuit Theory, on Communication Systems, and on Antennas and Propagation.

Ward, Wallise N. - *Field Engineering Representative,
Communication Laboratory*

Mr. Ward served in the U.S. Marine Corps from 1943 to 1945, as a rifleman. After leaving the service he was employed for nine years by the Weyerhaeuser Timber Company in Klamath Falls, Oregon, as a hooker, loading logs on trucks. From 1954 to 1956 he was employed in Eugene, Oregon, building and maintaining bridges. Subsequently, for three years, he worked again as a hooker, for the Ned Putnam Logging Company in Klamath Falls, Oregon. In 1959 he became a line inspector for the Johns Manville Company, inspecting materials from machines.

Early in 1962 Mr. Ward joined Stanford Research Institute. During this year he was a member of a rigging team erecting log-periodic antennas on 100-foot towers for a world-wide ionospheric sounder network. Later, at the SRI Mountain View, California field site, he assisted in operation and maintenance of communication equipment and an oblique-incidence ionosphere sounder. He was in charge of termination operations at the SRI field site in the Fiji Islands, when work at that site had been completed.

Wiley, Gordon S. - *Manager, Operations Analysis Department*

Mr. Wiley joined the staff of Stanford Research Institute in 1954. His work has been concerned with operational analysis of complex systems including military weapons systems, command-control-communication systems, and air-traffic-control systems. He has directed and performed operations analysis on such diverse problems and systems as helicopter navigation requirements, mine field techniques for low-altitude defense, operational environment of U.S. striking forces, and continental air and anti-missile defense systems. Mr. Wiley served as a member of the DOD R and E (communications) panel on Communication Switching. He is

currently concerned with study activities of national strategic command-control-communication systems, field army air defense weapons, and interpretive intelligence to provide criteria for system evaluation. As the program supervisor for the SRI Research Office, U.S. Army, CDEC, he provides direction to the scientific design and analysis of field experimentation on advanced warfare techniques.

Mr. Wiley received a B.S. degree in Electrical Engineering from the U.S. Naval Academy in 1941. From 1941 to 1954 he was an officer in the U.S. Navy, attaining the rank of Commander. During this time he attended the Radar Courses of the Radiation Laboratory of the Massachusetts Institute of Technology, the Naval Research Laboratory, and Camp Catlin, T.H., followed by three years as a Radar and CIC Officer. He qualified as a naval aviator, attending the All-Weather Flight School and later the Tactical Air Control School while serving in various aircraft squadrons. He took the Naval War College courses in Intelligence, Logistics, and Strategy and Tactics. He served on the staff of the Chief of Naval Air Technical Training as Training Officer, responsible for instructor training, training methods, and curriculum content involving thirty-two technical schools and the Naval Air Mobile Training Unit program. He later attended the Guided Missile School, Fort Bliss, Texas. Mr. Wiley served with the Operational Development Force as Project and Operations Officer of a squadron performing analysis and evaluation of weapons systems and tactics. He was assigned to the staff of the Director of Guided Missiles, Office of the Chief of Naval Operations, with responsibilities for formulating operational requirements and program management of guided-missile weapon systems.

Mr. Wiley is a member of the Operations Research Society of America, the U.S. Naval Institute, the Scientific Research Society of America, and the California Academy of Sciences and is listed in *American Men of Science*. He holds a commercial pilot's license with instrument rating.

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